MAR 27 1924

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
George K. Burgess, Director

TECHNOLOGIC PAPERS OF THE BUREAU OF STANDARDS, No. 251
[Part of Vol. 18]

EQUALIZER APPARATUS FOR TRANSVERSE TESTS OF BRICKS

BY

H. L. WHITTEMORE, Mechanical Engineer
Bureau of Standards

February 5, 1924

PRICE, 10 CENTS
$1.25 PER VOLUME ON SUBSCRIPTION
Sold only by the Superintendent of Documents, Government Printing Office
Washington, D. C.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1924

EQUALIZER APPARATUS FOR TRANSVERSE TESTS OF BRICKS.

By H. L. Whittemore.

ABSTRACT.

The American Society for Testing Materials has described the apparatus to be used for making transverse tests of building bricks. As this apparatus is made up of many loose parts, considerable time is required to prepare the next specimen for test.

A new equalizer apparatus has been designed, built, and tested, which gives practically the same values for the modulus of rupture as the A. S. T. M. apparatus. It consists of two equal arm levers about the length of the brick, mounted side by side on a pin at the middle of their length. At each end the levers have barrel-shaped knife edges carried on vertical spring-steel plates, which allow longitudinal movement of the knife edges. The levers equalize the four forces acting upward on the lower surface of the brick. The upper knife edge and the bearing plate are adjustable.

The time required for testing with this new apparatus was found to be about 58 per cent of that required if the A. S. T. M. fixture is used.

CONTENTS.

Page.
I. Introduction 107
II. A. S. T. M. apparatus 107
III. Equalizer apparatus 109
IV. Comparative tests of apparatus 111
  1. Modulus of rupture 111
  2. Time required 113
V. Summary 113

I. INTRODUCTION.

Those mechanical properties of building brick which are usually measured are the compressive strength and the modulus of rupture. The modulus is obtained by supporting the brick as a beam and loading it at the middle.

II. A. S. T. M. APPARATUS.

The American Society for Testing Materials in its specification for brick (C 21–20) describes for the transverse test the apparatus shown in Figure 1. The brick rests on two steel bearing plates, carried on two cast-iron wedges, which, in turn, are placed on the cylindrical upper surface of the wood block. On the brick, at the middle of the span, is a steel bearing plate; on it rests the upper loading wedge bolted to the movable head of the testing machine.

To obtain correct results, the action lines of the two reactions or forces acting upward on the ends of the brick and the action line of the downward load or force at the middle of the brick must be vertical; also, the distance between the action lines of the two reactions must be accurately known, and the action line of the load must pass through the middle of the span and lie in the plane of the reactions.

If the brick, while being loaded transversely, is under axial stress, either tension or compression, along the longitudinal axis of the brick, the load required to cause failure would not be the same as without this stress. If the axial force is tension, the tensile stress in the lower portion of the brick is increased; if compression, this tensile stress is decreased. The ultimate load at the middle of the span is, in the first case, less than without the axial stress and in the latter case greater. This is due to the fact that the tensile strength of brick is less than the compressive strength.

Brick, like all other materials, is deformed by applied forces. Under transverse loading a brick is deflected downward at the middle. This causes the two end bearing plates to move apart. If this movement is prevented, the effect is the same as applying an axial compressive stress to the brick and the ultimate load at the middle is increased.

The parts of the A. S. T. M. apparatus must be accurately placed to obtain correct results. None of the parts should be permanently deformed by the loads. For example, if hollows are formed in the upper surface of the wood block, the action lines of the two end reactions are not necessarily vertical. If they are inclined, they can be resolved into two components, one vertical and the other horizontal. The latter, causing either tensile or compressive axial stresses in the brick, would, as explained above, affect the ultimate load at the middle of the span. Even if the action lines of the reactions are vertical at the beginning of the test, the tendency of the two bearing plates to separate rocks the cast-iron wedges so that the centers of their bearings on the wood block are moved outward. As these action lines must also pass through the upper edges of the wedges, the result is a horizontal component tending to compress the brick and to increase

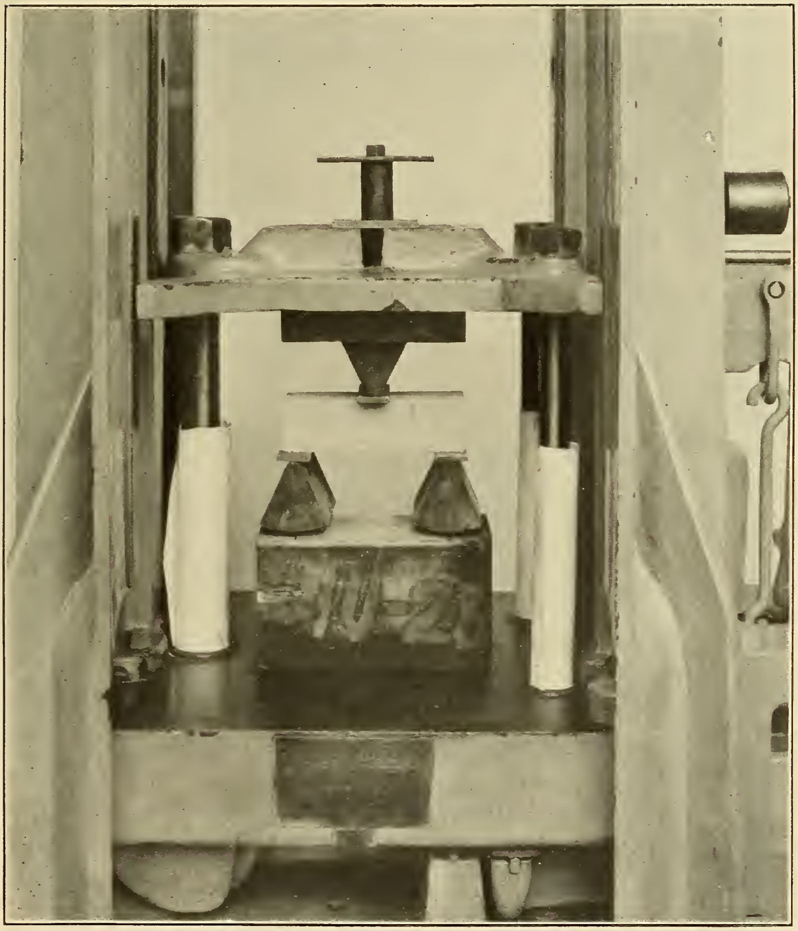

FIG. 1.—*A. S. T. M. apparatus for making transverse tests of building brick.*

Before fracture of the specimen.

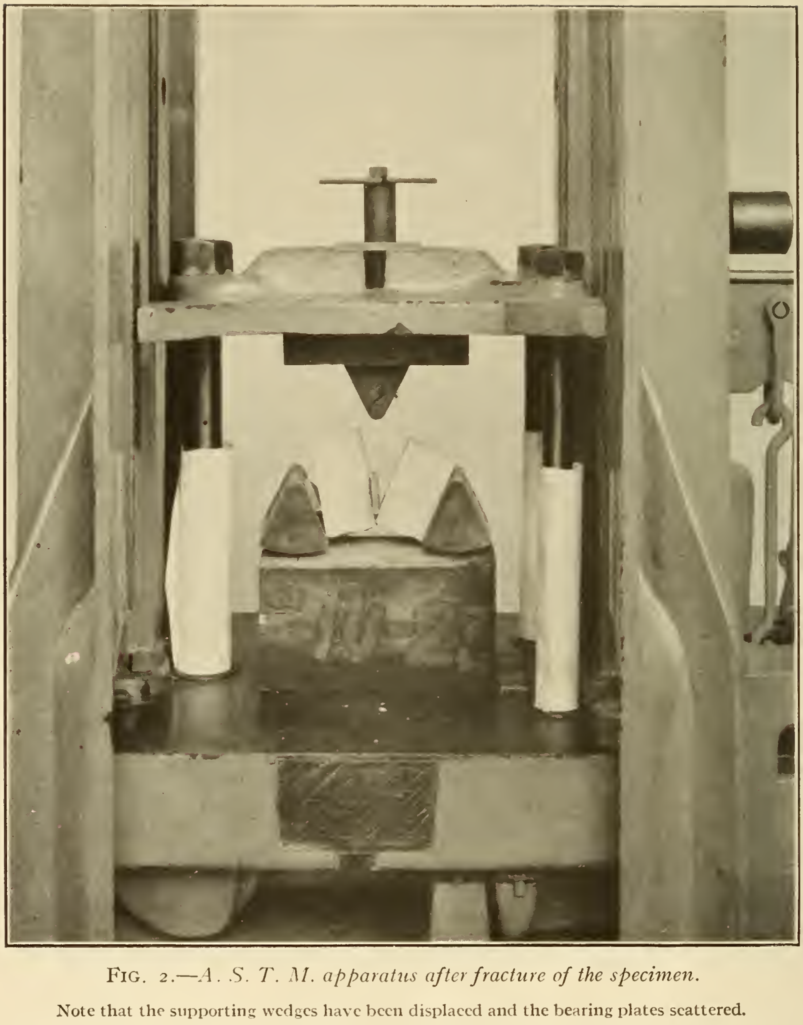

FIG. 2.—*A. S. T. M. apparatus after fracture of the specimen.*

Note that the supporting wedges have been displaced and the bearing plates scattered.

the load at the middle of the span which is necessary to cause failure. Hollows in the wood block also tend to prevent rocking of the wedges on the cylindrical surface of the wood block. This might move the action lines of the reactions transversely with respect to the brick, even if they remained vertical, so that the plane of the action lines of the two end reactions might not coincide with the vertical longitudinal axial plane of the brick. It is evident that if this plane passes through one of the vertical faces of the brick, the load required to cause failure is much less than if the test is correctly made.

As the parts of the A. S. T. M. apparatus are not mechanically connected, failure of the specimen throws them out of position, as shown in Figure 2, necessitating complete readjustment of the apparatus for each brick tested.

III. EQUALIZER APPARATUS.

The new equalizer apparatus (shown in figs. 3 and 4) was designed to maintain the supports in their correct positions and also to obtain more uniform conditions of specimen loading than can be obtained with the A. S. T. M. apparatus.

The brick is placed on four barrel-shaped bearings, each carried on a plate fulcrum. No bearing plates are used for these, as experience has shown that the bricks do not spall at these bearing points. The fulcrums (0.050 by 1.5 inches) were cut from tempered clock spring and driven into their seats in the bearing and in the levers. The seat in the lever is relieved on the outside to allow deflection of the fulcrum as the brick deforms. The estimated deflection of the fulcrums during tests was 0.01 inch. The horizontal force required to give this deflection was 20 pounds. This constraint, tending to increase the apparent strength of the specimen, is negligible compared with a load, for example, of 1,200 pounds. The seats in the levers were not relieved on the inside, as under excessive loads both fulcrums might deflect in the same direction and failure of the fulcrums follow. Any débris which falls upon the seats can be easily removed and will not accumulate between the beam and the fulcrum, displacing the latter.

The beams, having a bearing at each end, rotate independently on the horizontal pin which lies in a seat in the base. The function of these levers is to equalize the four forces acting on the

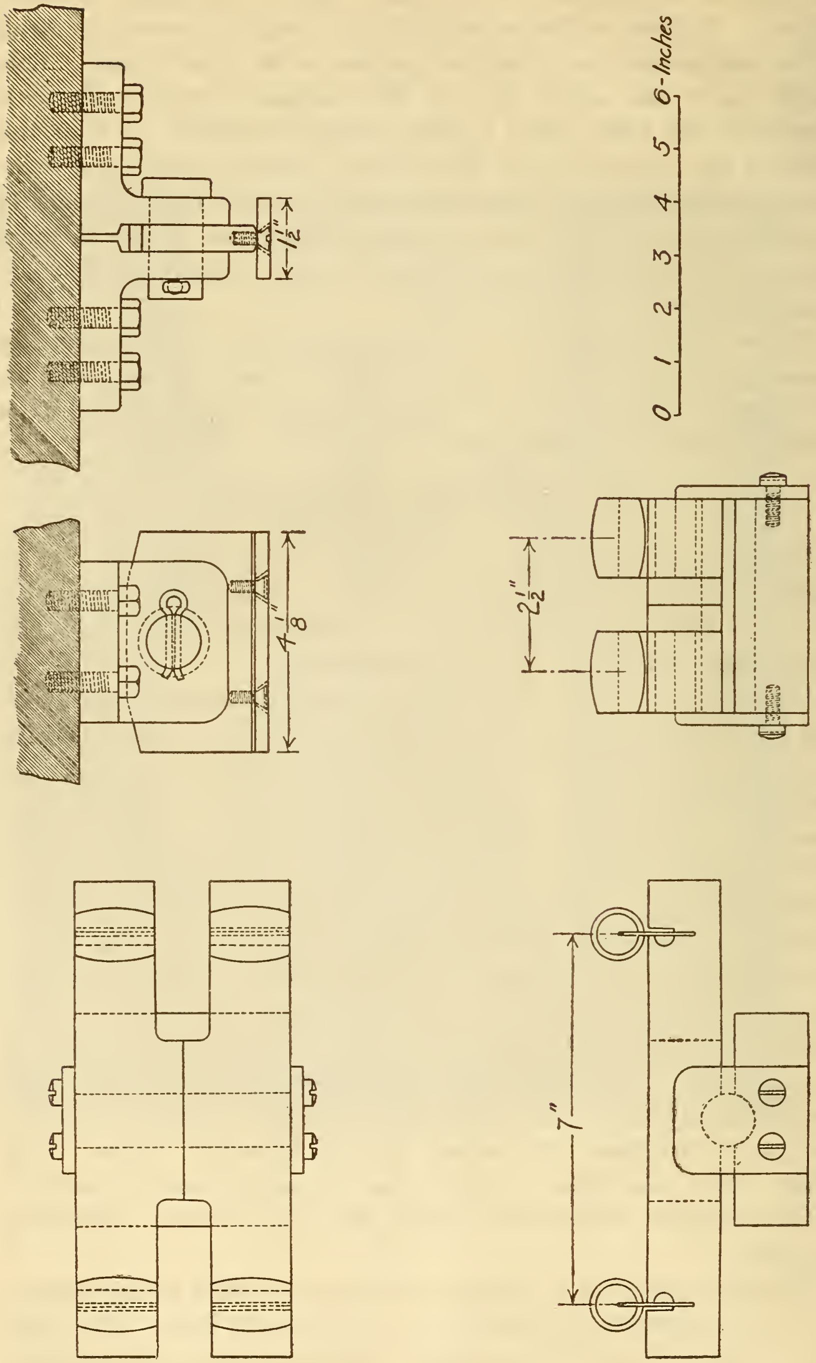

Fig. 3.—*Drawing of equalizer apparatus.*

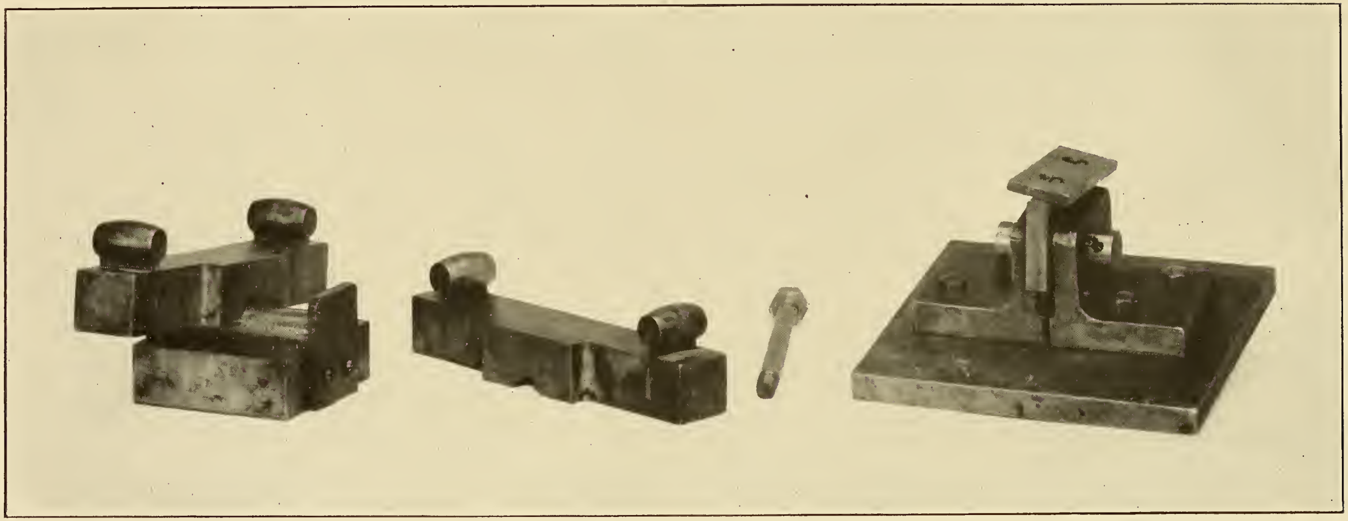

FIG. 4.—*The equalizer apparatus.*

Left to right—the support with one lever removed to show the construction; cap screw to hold upper bearing in the testing machine; the upper bearing showing the adjustment of the bearing and bearing plate.

lower surface of the brick. The resultant of the two forces at one end of the brick is therefore midway between them and, if the brick is correctly placed in the apparatus, coincides with the vertical axial plane of the brick. The beams adjust themselves automatically, even if the surface of the brick is warped or irregular.

If the bricks are to be tested flatwise, the projecting hubs of the levers are placed together, thus separating the bearings, as in Figure 3. If the bricks are to be tested edgewise, the levers are interchanged on the pin, thus bringing the bearings nearer together.

The upper bearing, at the middle of the brick, is self-adjusting about the pin carried by the movable head of the testing machine, and a bearing plate is attached loosely to the lower edge by countersunk screws. This bearing plate is necessary, as the load may cause spalling, which would decrease the strength of the brick.

The equalizer apparatus with a brick in position is shown in Figures 5 and 6. As the fracture of the brick does not shift any part of this apparatus, no adjustment is necessary for the next test. It is only necessary to raise the head of the machine, place another brick in position, apply the load, and observe the maximum.

IV. COMPARATIVE TESTS OF APPARATUS.

1. MODULUS OF RUPTURE.

Using the A. S. T. M. and the equalizer apparatus, 197 clay bricks, 200 cement bricks, and 98 sand-lime bricks were tested, under comparable conditions, with the results shown in Tables 1 and 2. In 3 of the 5 lots the equalizer gave a higher value and in 2 a lower value for the modulus than was obtained for the A. S. T. M. apparatus, the maximum deviation from the mean being 6.9 per cent. The dispersion of the test results for the individual bricks was in 3 lots greater for the equalizer apparatus and in 2 lots greater for the A. S. T. M. apparatus. These tests, therefore, show no significant differences in the results obtained for the 2 types of apparatus.

TABLE 1.—Strength of Clay Bricks.

Modulus of rupture range (lbs./in.^{2}).	Number of bricks in each rupture range			
	Tested flatwise with—		Tested edgewise with—	
	A.S.T.M. apparatus.	Equalizer apparatus.	A.S.T.M. apparatus.	Equalizer apparatus.
50–149				
150–249		1		
250–349	1			1
350–449	2	1	7	7
450–549	12	8	4	4
550–649	12	11	8	7
650–749	4	8	9	11
750–849	6	7	4	5
850–949	4	1	7	4
950–1,049	4	3	4	2
1,050–1,149	4	2	2	2
1,150–1,249		3		2
1,250–1,349	1	1	2	1
1,350–1,449		1		1
1,450–1,549			1	1
1,550–1,649		1		
1,650–1,749		2		1
1,750–1,849				
Number of bricks tested	50	50	48	49
Maximum modulus	1,315	1,726	1,481	1,691
Minimum modulus	335	246	369	327
Average modulus	707	793	736	751
	750		744	
Deviation from average modulus per cent	+5.7		+0.9	

TABLE 2.—Strength of Cement Brick and of Sand-Lime Brick.

Modulus of rupture range (lbs./in.^{2}).	Number of cement brick in each rupture range.				Number of sand-lime brick in each rupture range tested flatwise with—	
	Tested flatwise with—		Tested edgewise with—			
	A.S.T.M. apparatus.	Equalizer apparatus.	A.S.T.M. apparatus.	Equalizer apparatus.	A.S.T.M. apparatus.	Equalizer apparatus.
275–324			1			2
325–374			6		1	1
375–424	2	1	13	6	2	3
425–474	3	7	15	11	7	3
475–524	4	7	7	11	9	10
525–574	17	17	4	12	8	6
575–624	10	11	3	7	11	6
625–674	13	4	1	3	8	12
675–724	1	2			1	5
725–774		1			1	
775–824						
825–875					2	
Number of bricks tested	50	50	50	50	50	48
Maximum modulus	705	740	670	672	843	718
Minimum modulus	389	413	305	386	352	282
Average modulus	572	553	448	513	561	554
	563		480		558	
Deviation from average modulus, per cent	−1.8		+6.9		−0.7	

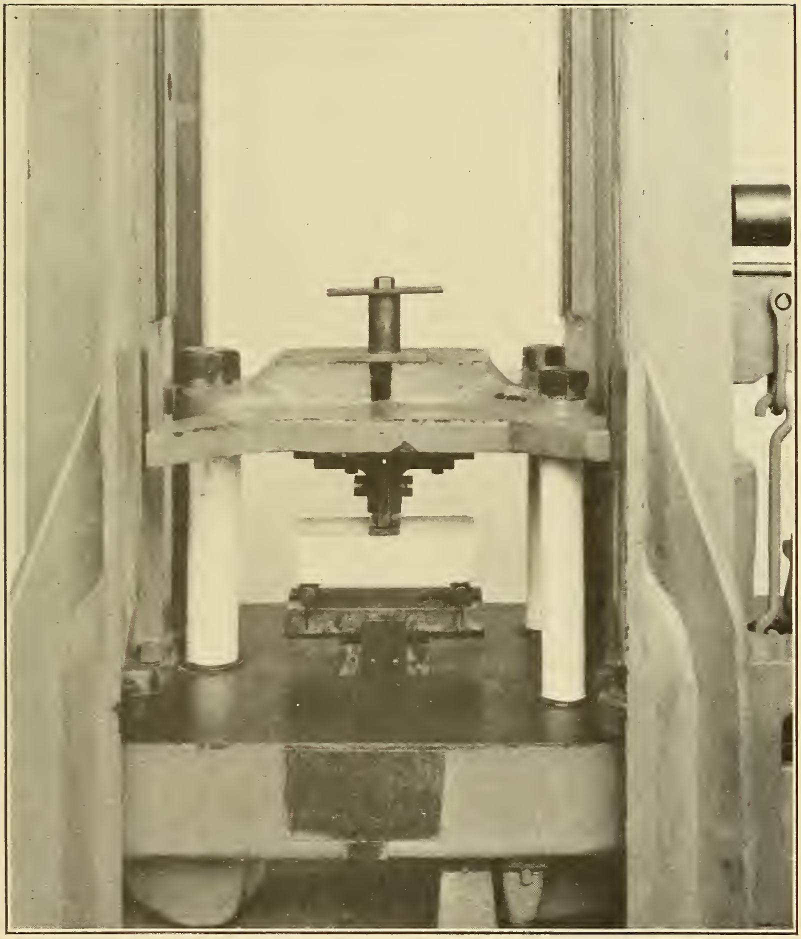

FIG. 5.—*Equalizer apparatus before fracture of the specimen.*

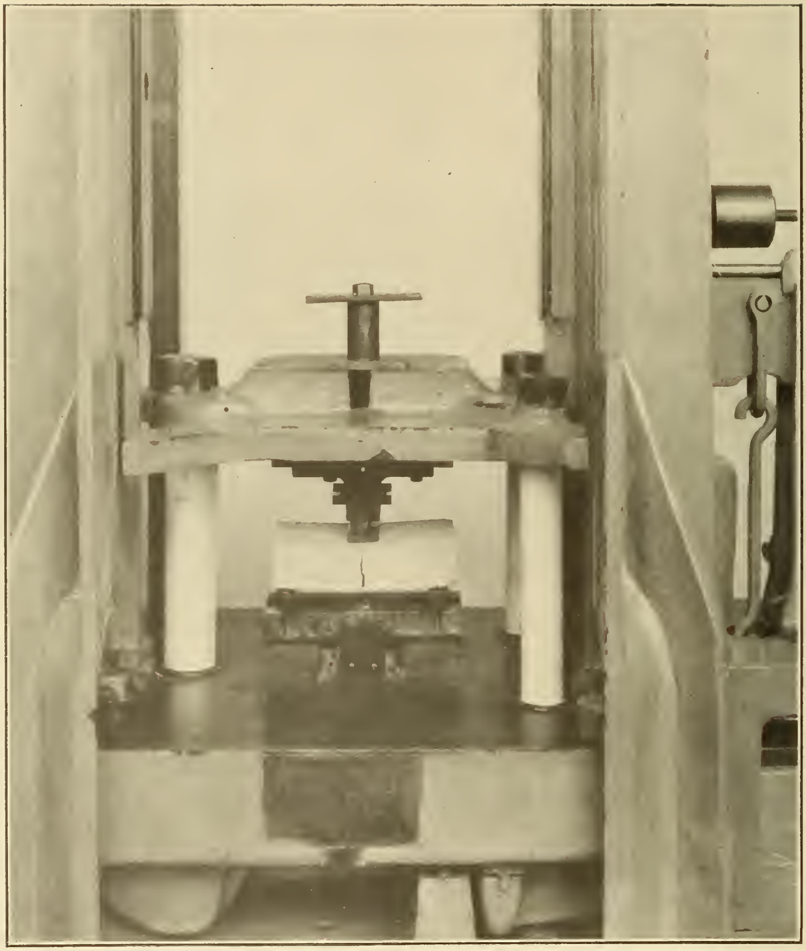

FIG. 6.—*Equalizer apparatus after fracture of the specimen.*

Note that the bearings have not been displaced. To test the next brick run the head up and place brick in position, then apply load.

2. TIME REQUIRED.

In making the comparative tests the testing-machine operator tried to work as rapidly as was consistent with obtaining reliable readings. The time required to test 50 cement bricks in each lot, using the A. S. T. M. apparatus, was 2 hours and 30 minutes flatwise and 2 hours and 45 minutes edgewise. The corresponding times, using the equalizer, were 1 hour and 27 minutes and 1 hour and 35 minutes. Forty-two per cent of the testing time was, therefore, saved by using the equalizer apparatus.

V. SUMMARY.

1. A new equalizer apparatus for transverse tests of building bricks is illustrated and described. It is designed to insure proper loading, even if the surfaces of the brick are warped or irregular, and to maintain the proper distance and alignment of the bearings.

2. Comparative tests showed that for clay, cement, and sand-lime bricks the modulus of rupture obtained with the equalizer apparatus was practically the same as that found with apparatus made in accordance with the recommendations of the American Society for Testing Materials.

3. With the same effort on the part of the testing-machine operator, the time required to test bricks with the equalizer was 58 per cent of that required with the A. S. T. M. apparatus. This saving of 42 per cent was due to the new design which eliminated loose parts.

WASHINGTON, October 29, 1923.

⁂